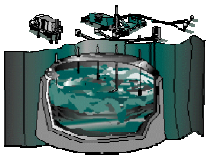
Dual-Point Impedance Control for Telerobotics



Developer: University of Tennessee
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Crosscutting Area: Robotics

Tanks FOCUS AREA

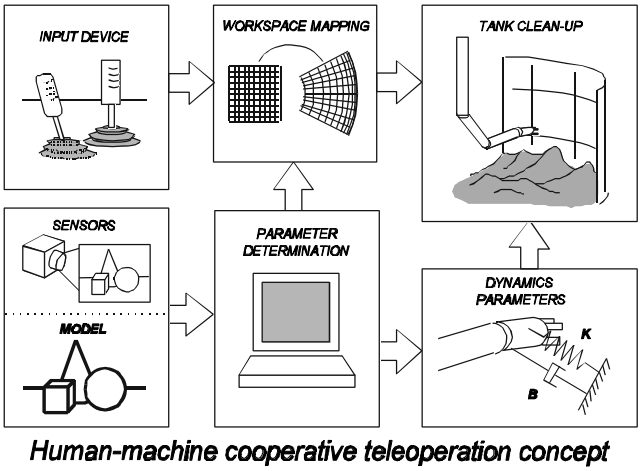
Problem:

Radioactive tank waste remediation, decontamination and decommissioning (D&D) of contaminated Department of Energy (DOE) facilities, and other nuclear cleanup tasks will require remote handling technologies extensively. The unstructured nature of these tasks and limitations of the current sensor and computer decision-making technologies prohibit the use of completely autonomous systems for remote manipulation.

Teleoperated systems, or those in which humans are an integral part of the control, are currently used for performing these tasks. However, these systems are difficult to operate and make simple manipulation operations tedious and time consuming, thus, greatly increasing the costs and operator fatigue.

Solution:

Develop a methodology to incorporate sensor and model based computer assistance into human controlled teleoperator systems. In this approach, human operator input is enhanced but not superseded by the computer. This form of assistance is provided by adjusting system parameters that are not under direct control by the operator, such as impedance parameters and workspace mappings between the master and slave manipulators. Such supervisory control is different from (but can coexist with) traded control, where the human from time to time relinquishes control to the computer or shared control. Using supervisory control, the human may act as a supervisor with respect to control of some variables and direct controller with respect to other variables.



Human-machine cooperative teleoperation concept

The basic approach is to use available but incomplete and imperfect sensory and model data to assist the operator's motions, while the operator retains direct control of the manipulator. Since the operator always maintains direct control, fully intelligent computer decision making is not required. Note that the assistance is passive in the sense that the end-effector does not move unless provided a command from the human operator.

Benefits:

The new technology for teleoperation would help the tank waste remediation, D&D, and other nuclear cleanup tasks in the following ways:

▸Increased efficiency and lower costs: Several tasks such as attaching different tooling to the Modified Light-Duty Utility Arm (MLDUA), avoiding risers and other obstacles, maintaining desired distance from tank walls, precise positioning of the water jet, etc., could be performed much faster. Similarly, a variety of D&D tasks such as drilling, sawing, unbolting, etc., could be performed with increased efficiency. For example, avoiding saw binding and maintaining proper blade depth for teleoperated aluminum reactor vessel cutting task done at Chicago Pile 5 (CP-5) should benefit from the proposed technology.

▸Improved safety: Sensor assistance would result in safer teleoperation due to obstacle avoidance and reduction in impact forces during contact.

▸Lower operator fatigue: The proposed system would assist the operators in performing tasks with significant reduction in fatigue.

Technology:

A real-time telerobotic controller is being developed to incorporate several types of sensory and model information for assisting the human operator through intelligent mapping of the master commands to the remote manipulator motion. It also adjusts the dynamics parameters of the remote manipulator based on the sensory and model inputs.

In the first year, this controller will be implemented on a testbed consisting of a seven-degree-of-freedom Robotics Research Corporation manipulator and a six-degree-of-freedom force reflecting Kraft hand controller. The sensor suite consists of a vision system, laser range finder, force/torque sensors, and ultrasonic sensors. The C code for the algorithm is being developed using ControlShell, a real-time control software package, within a VME/VxWorks environment, and will be compatible with the tank remediation and the D&D systems at Oak Ridge National Laboratory (ORNL).

The types of assistance expected to be offered by this technology include optimal trade-offs in workspace volume and motion resolution, avoidance of hard impacts, assistance in tool alignment with precision tasks while preserving the operator's ability to finely adjust the position, obstacle avoidance, and automatic adjustment of dynamics parameters to optimally suit current working conditions.

Comparison studies will be developed between standard teleoperation and the proposed computer assisted teleoperation to verify advantages with respect to task efficiency, operator fatigue, and safety. Specific mock-up experiments will be developed based on the task needs in tank-waste cleanup and D&D and the potentially available sensors.

In the second year, the University of Tennessee will test the computer assisted teleoperation on the simulator for the MLDUA at ORNL, and then implement the control algorithm on the actual hardware, provided the simulation results are positive. Another task will be to implement the new controller on the Dual Arm Work Module (DAWM) at ORNL and verify operability in D&D activities by field testing the system.

Contacts:

Researchers at the University of Tennessee have been developing control strategies for advanced telerobotic systems for over 10 years. They have worked closely with ORNL and other national laboratories, and NASA on the development and implementation issues for remote manipulation systems. For information on this project, the contractor contact is:

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